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Evaluation of Fish Behaviour and Aggregation by Underwater Videography in an Artificial Reef in Tioman Island, Malaysia

(Penilaian Tingkah Laku dan Pengagregatan Ikan Menggunakan Videografi dalam Air Pada Tukun Tiruan di Pulau Tioman, Malaysia)

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ABSTRACT

The behaviour and aggregation of fish in an artificial reef area in Tioman Island, Malaysia, was observed using underwater videography under a combination of shooting conditions. The camera distance and direction relative to the neighboring artificial reef module was varied, and comparisons of images with a color filter were made. A distance of 260 cm at a diagonal shooting angle provided a suitable observation of the reef fish around the reef module, and a red color filter provided a truer color replication in morning observations while better images were obtained without the color filter in afternoon light environments. Four criteria were considered to assess the artificial reef effectiveness: total abundance, appearance rate, residence time and feeding frequency. A total of 824 individuals were observed during the study. Mean residence times were shorter for schooling fishes such as Caesio caerulaurea *and* Liza subviridis, *and longer for solitary swimmers like* Cephalopholis boenak *and* Scolopsis bilineatus. *Feeding frequency was lower for schooling fishes. A significant correlation was obtained between the feeding frequency and residence time for the high feeding frequency fishes ($r = 0.89$; $p<0.05$). The effectiveness of the artificial reef was suggested to be significant in solitary swimmers but less so for schooling fishes.*

Keywords: Artificial reef; fish aggregation; Tioman Island; underwater videography

ABSTRAK

Tingkah laku dan pengumpulan ikan dalam satu kawasan tukun tiruan dalam Pulau Tioman, Malaysia, telah cerap dengan menggunakan videografi dalam air dengan gabungan daripada berberapa keadaan penggambaran. Jarak dan arah kamera relatif kepada modul tukun tiruan berjiranan adalah berbeza, dan perbandingan antara imej video diperhatikan dengan menggunakan penuras warna. Jarak 260 cm pada sudut penggambaran diagonal memberikan pemerhatian yang sesuai untuk ikan di sekitar modul tukun tiruan, dan penuras berwarna merah memberikan replikasi warna yang lebih sesuai dalam pemerhatian pada waktu pagi manakala imej yang lebih baik diperolehi tanpa menggunakan penuras warna dalam persekitaran cahaya petang. Empat kriteria diambil kira bagi menilai keberkesanan tukun tiruan: jumlah kelimpahan, kadar kewujudan, masa mastautin dan frekuensi memakan. Sejumlah 824 individu ikan telah dicerap dalam kajian. Min masa mastautin adalah lebih pendek untuk ikan-ikan seperti Caesio caerulaurea *dan* Liza subviridis, *dan lebih panjang untuk perenang secara sendirian seperti* Cephalopholis boenak *dan* Scolopsis bilineatus. *Frekuensi memakan adalah lebih rendah untuk ikan kawanan. Kolerasi bererti diperolehi antara frekuensi memakan dan masa mastautin untuk ikan-ikan berfrekuensi memakan tinggi ($r = 0.89$; $p<0.05$). Keberkesanan tukun tiruan dicadangkan penting untuk ikan perenang secara sendirian tetapi kurang penting untuk ikan kawanan.*

Kata kunci: Kumpulan ikan; Pulau Tioman; tukun tiruan; videografi dalam air

INTRODUCTION

Artificial reefs are submerged structures placed on seabed deliberately to mimic some characteristics of natural reefs (Jensen 1997). A principal reason for the deployment of such reefs is to improve, increase or maintain the fisheries resources in a local area. As artificial reefs attract and concentrate small coastal pelagic fish, they are useful for monitoring the state of the resource and help provide better stock assessments (Tessier et al. 2005). Furthermore, fish diversity and abundance in damaged natural reef could be restored by utilization of artificial reef (Rilov & Benayahu 2000). Since the observation of reef associated fish is important in both socio-economic and biological understanding of reef productivity, a suitable method of evaluating population abundance and effectiveness of artificial reef is needed.

Underwater visual census (UVC) methods have been used extensively in reef fish studies of population dynamics, ecology and management (Parker 1990; Thresher & Gunn 1986). In a fisheries context visual census estimates of fish abundance are particularly useful because they are independent of fishing methods. Other benefits include: cheap to perform; do not require subsequent lab-work; useful in rapid estimates of relative abundance, biomass and length frequency distributions. However, it also has some limitations which include constraints of scuba diving, tendency to miss small or cryptic species (Brock 1982), observer's identification, counting and recording errors (Russell et al. 1978), and species-specific variability in the attraction or escape response to the presence of divers (Chapman et al. 1974; Francour et al. 1999).

There has been a sharp increase in recent years in the number of studies using video devices to study shallow water marine flora and fauna due to the advent of relatively inexpensive digital devices and the availability of better image processing software. Video records allow better standardization of data collection over long time series and permanent records of the fish observed are obtained without destroying the fauna. Takagi et al. (1997) used stationary and roving underwater video cameras to observe fish behavior in artificial reefs and suggested that it was particularly useful in extended observations without the limitations of scuba diving to understand the association of fish with the artificial reef.

Many different types and designs of artificial reefs have been tested or are currently deployed throughout the world (Baine 2001). By far, the most favored reef material is concrete shaped as cubes, blocks and pipes. Concrete are also used in combination with other reef materials such as vessels, quarry rock and plastic. The wide range of materials used confirms the varied approach to the creation of artificial reefs. In Ranong Province, Thailand, reinforced concrete cubical modules as artificial reefs were successful in enhancing the fish aggregation and showed a positive effect on the biosocioeconomics of the region (Satapoomin 1997), while artificial reef utilizing rubber tire modules was a failure in Fort Luaderdale, Florida (*International Herald Tribune* 18-02-2007) with little marine life forming on the tires. Fish enhancement was also found to be more effective in concrete modules than tire reefs in Singapore (Chua & Chou 1994).

The performance of individual reef unit designs may vary considerably, depending on their specific characteristics as well as location of deployment and intended results (Bell et al. 1989; Bell & Hall 1994) and each artificial reef program must be evaluated for the need, feasibility and cost-benefits.

Malaysian interest began in the 1970s and 60,000 tires were used in 40 artificial reef sites by 1986. A nationwide program for the construction of artificial reefs was included in the Fifth Malaysian Plan (1986-1990). Ninety percent of the reefs are of tires and the rest of concrete modules and scrap vessels (Ch'ng & Thomas 1990). One of the first major projects was carried out in 1998 where 1500 artificial "reef balls" were deployed for the first time in Asia (Sarawak Tribune 18-06-1998). Many artificial reefs have been deployed throughout peninsular Malaysia since then. However, the effectiveness or performance of these reefs has not been evaluated properly.

This study focused on a selection of species that are found commonly in the coral reefs around Tioman Island. To establish some generalizations about underwater videography methods, we examined the problems of video capture observation of reef fishes using a systematic combination of approaches to provide an evaluation of the underwater videography method.

Materials and Methods

Sampling was carried out at an artificial reef in the Marine Park at Tioman Island on the east coast of Peninsular Malaysia (Figure 1). The coral reefs around the island are typical fringing reefs (De Silva 1982). The area surrounding the Marine Park is dominated by *Acropora* and *Montipora* corals, and live coral coverage was 31 % in a study carried out in 2001 (Toda et al. 2007). There are thirty artificial reef modules which were deployed since 1997 near the Marine Park jetty (mean depth 5 m). The submerged modules are ca. 1 m ×1 m (height × width) and resemble tables and chairs which are collectively nicknamed "underwater restaurant" by the locals (Figure 2).

For our analyses, we varied the camera distance and direction relative to the neighboring artificial reef module. Secondly, we compared video images with and without a color filter and wide angled lens. Thirdly, we used four criteria to assess the artificial reef effectiveness: total abundance, appearance rate, residence time and feeding frequency.

Experimental Design

A base plate was fixed onto the artificial reef module where the video camera was attached and supported by a flexi-arm (Figure 3). We used a Sony DCR-PC120 high-resolution Mini-DV video camera with Sony wide 0.7× conversion lens mounted in a SEA & SEAVX-PC110 video housing. The flexi-arm allows for height, distance and angle adjustments so that the video camera captures a focused image of the neighboring artificial reef module. The study was conducted from 23 to 25 August 2001. For the first two days, we tested for twelve different shooting conditions (Table 1) in order to find the most suitable method to evaluate the effectiveness of the artificial reef. On the last day, uninterrupted video recordings, each of two-hour length, were conducted at 1000 hr and 1500 hr which correspond to the ebb and high tide, respectively.

Video data analysis All reef associated fishes were identified to species as far as possible. Individuals unidentifiable due to poor image focus were classified as unidentified species. The appearance rate, residence time and feeding frequency were estimated. The appearance rate

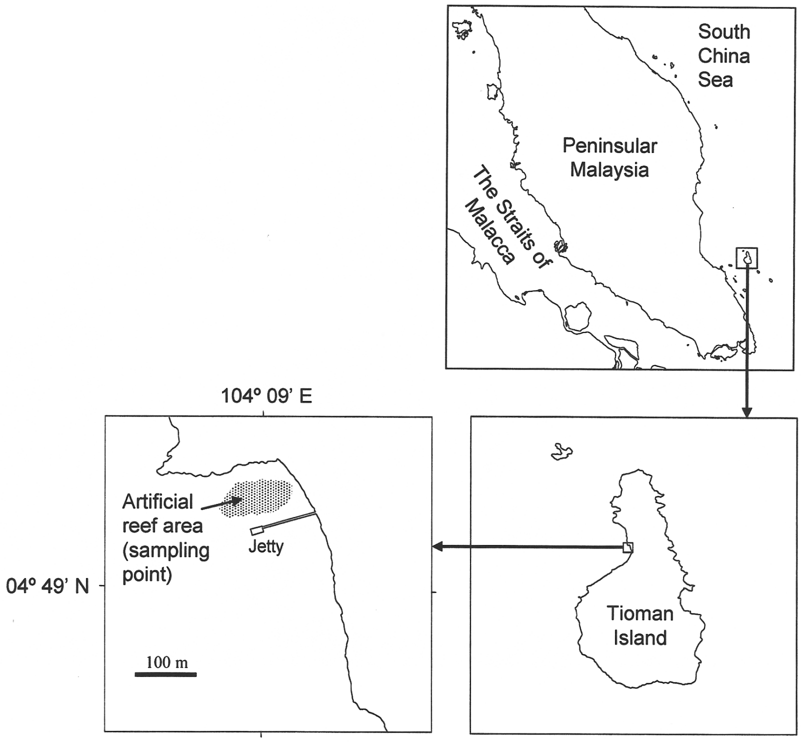

FIGURE 1. Location of sampling site

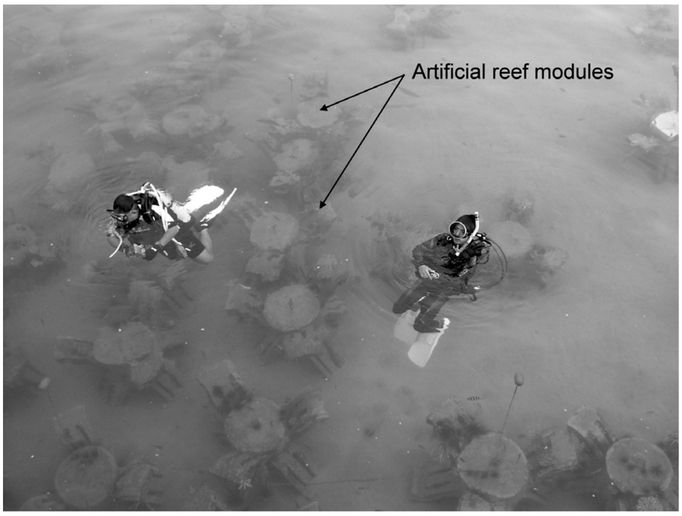

FIGURE 2. Image of the "underwater restaurant"

(inds h^{-1}) of each species was estimated by dividing the total number of individuals observed with video recording time. The average residence time (sec ind^{-1}) was derived by dividing the total residence time with the total number of individuals of each species. The number of bites on the artificial reef module was counted and recorded as feeding occurrences. The total feeding occurrence and the total individual number was observed for each species to calculate the feeding frequency (%).

RESULTS

SHOOTING CONDITIONS

Horizontal vs. diagonal view Due to resuspension of the sea bottom, the horizontal view was less clear compared to the diagonal view (Figure 4). Moreover, the image of the artificial reef module takes up a larger relative area of the horizontal view compared to the diagonal view, reducing

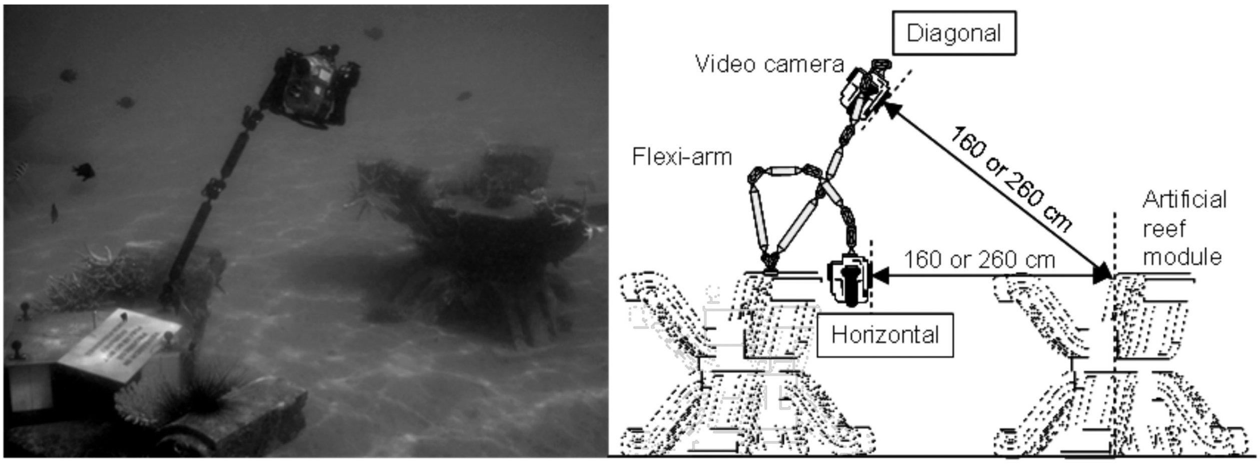

FIGURE 3. Videography setup on the artificial reef module

TABLE 1. Various combinations of shooting conditions examined in this study

No	Distance to neighbour reef module (cm)	View	Filter	Lens	Recording time (min)
1	160	Horizontal	Red colour filter	Wide lens	20
2	160	Horizontal		Wide lens	20
3	160	Diagonal	Red colour filter	Wide lens	20
4	160	Diagonal		Wide lens	20
5	260	Horizontal	Red colour filter	Wide lens	20
6	260	Horizontal		Wide lens	20
7	260	Horizontal	Red colour filter		20
8	260	Horizontal			20
9	260	Diagonal	Red colour filter	Wide lens	20
10	260	Diagonal		Wide lens	20
11	260	Diagonal	Red colour filter		20
12	260	Diagonal			20

the effective field of view and obstructing the observation of fish behind the module. On the other hand, there was less influence of re-suspended particles for the diagonal view and an extended depth of view was achieved, permitting the observation of fish that go behind the module.

Distance to object of video camera We compared two distances between the video camera and the artificial reef module. The distance of 260 cm increased the effective field of view but reduced the visibility of the image compared to the distance of 160 cm (Figure 5).

With and without colour filter (red) We examined the feasibility of using a red colour filter on the quality of the video images. The colour of the artificial reef and the associated reef fishes were realistically reproduced using the red color filter in the morning (1000hr). However, a truer color replication was achieved without the red color filter during the afternoon video recording (1500hr).

DATA ANALYSIS

SPECIES IDENTIFICATION

Twelve types of fishes were identified, 8 of which could be determined to the species level from 7 genus levels. The other four types could be identified only to the genus level (Table 2). The species observed in this study are commonly found in reef areas in tropical and sub-tropical regions. Among the observed species, *Caesio caerulaura* and *C. teres* are from the Family Caesionidae and are usually found wandering in schools of 20-30 fishes in shallow reef and rocky-bottom areas. *Siganus guttatus* and *Liza subviridis* are species which also show similar behavioral

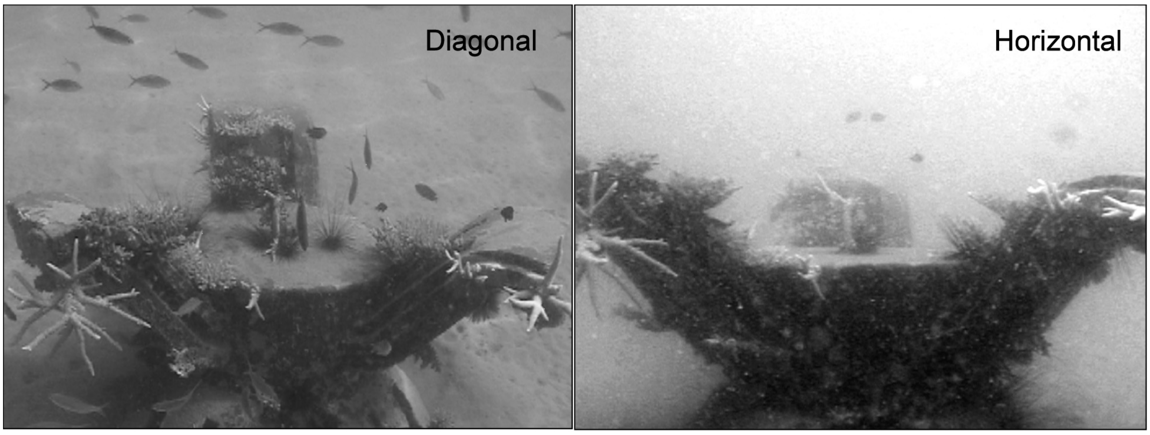

FIGURE 4. Comparison of the video camera angle relative to the artificial reef module

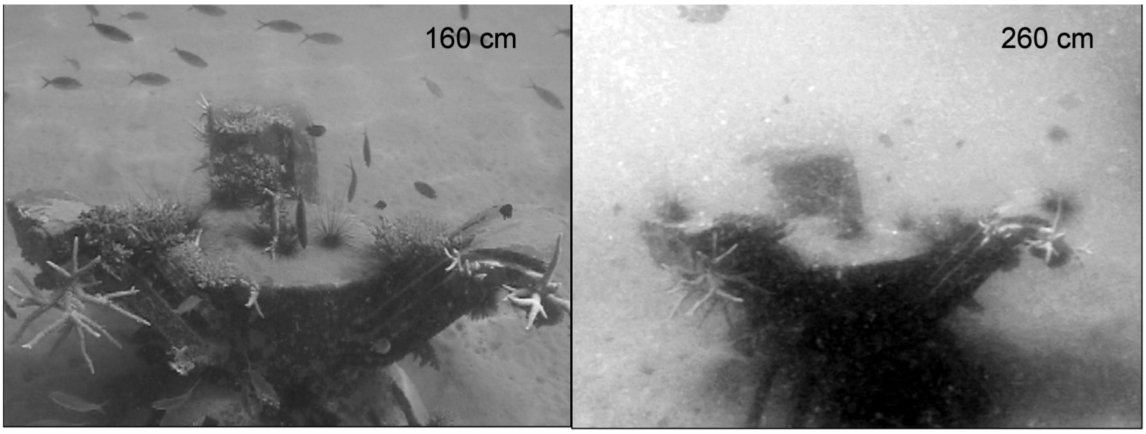

FIGURE 5. Comparison of the video camera distance relative to the artificial reef module

traits. On the other hand, *Cephalopholis boenak* belonging to the Family Serranidae, is a solitary swimmer and a bottom-dweller, usually found in the crevices of coral reefs which also acts as its feeding ground. Other such fishes observed include *Scolopsis bilineatus* and *Lutjanus* sp.

Dasyatis sp., *Labroides dimidiatus* and *Monodachtylus argenteus* were absent in the morning observation, while *Caesio caerulaurea* was not observed in the afternoon (Table 2). The rate of cumulative species appearance was higher in the afternoon observation (Figure 6), though the asymptotes were not reached during both surveys.

APPEARANCE RATE, RESIDENCE TIME, FEEDING FREQUENCY

A total of 824 individuals were observed during the four hour video recording (Table 2). The most abundant taxa around the artificial reef were *Caesio caerulaurea* which amount to 233 individuals, followed by *Liza subviridis* (113 inds.), *Siganus guttatus* (96 inds.) and *Scarus* sp. (91 inds.). Mean residence times were generally shorter for schooling fishes such as *Caesio caerulaurea*, *Siganus guttatus*, *Liza subviridis*, and longer for solitary swimmers like *Cephalopholis boenak*, *Scolopsis bilineatus*, *Lutjanus* sp. A bimodal distribution in feeding frequency was observed; a high and low feeding frequency group (Figure 7). Schooling fishes were clustered in the low feeding frequency group while solitary swimmers had high feeding frequency (Table 2). A significant correlation was obtained between the feeding frequency and ln-transformed residence time for the high feeding frequency group ($r = 0.89$; $p<0.05$).

DISCUSSION

VIDEOGRAPHY METHOD

The horizontal view was notably affected by the re-suspension of bottom sediments compared to the diagonal view. The diagonal view also provides a deeper and wider field of view, allowing for observation of fishes behind the artificial reef module. Difficulty in identification was not substantially different between the horizontal and diagonal view Therefore, in terms of the angle of shooting, video recording from the diagonal view is considered a better video recording method.

TABLE 2. Appearance rate, residence time and feeding frequency of reef fish from the video observation

Species	Total individuals (inds.)			Appearance m rate (inds. h^{-1})			Residence time (sec ind^{-1} ± S.D.			Feeding frequency (%)		
	1000 h	1500 h	Combined	1000 h	1500 h	Combined	1000 h	1500 h	Combined	1000 h	1500 h	Combined
Caesio caerulaurea	233	0	233	116.5	0.0	58.3	5.40	0.0	5.4 ± 3.9	2	0	2
Caesio teres	1	22	23	0.5	11.0	5.8	1.6	3.9	3.8 ± 2.2	0	0	0
Cephalopholis boenak	14	20	34	7.0	10.0	8.5	48.9	39.1	43.2 ± 58.3	93	20	50
Dasyatis sp.	0	1	1	0.0	0.5	0.3	0.0	8.0	8.0 ± 0	0	0	0
Labroides dimidiatus	0	6	6	0.0	3.0	1.5	0.0	7.2	7.2 ± 3.3	0	0	0
Labroides sp.	33	14	47	16.5	7.0	11.8	9.1	8.3	8.9 ± 8.5	52	14	40
Liza subviridis	26	87	113	13.0	43.5	28.3	7.5	11.4	10.5 ± 6.8	0	0	0
Lutjanus sp.	9	10	19	4.5	5.0	4.8	11.8	6.9	9.2 ± 6.9	44	20	32
Monodachtylus argenteu	0	3	3	0.0	1.5	0.8	0.0	2.8	2.8 ± 0.5	0	0	0
Scarus sp.	54	37	91	27.0	18.5	22.8	15.4	15.2	15.3 ± 15.4	43	30	37
Scolopsis bilineatus	37	19	56	18.5	9.5	14.0	33.4	21.1	29.2 ± 23.5	57	26	46
Siganus guttatus	48	48	96	24.0	24.0	24.0	5.3	3.5	4.4 ± 2.5	0	0	0
Unknown species	29	73	102	14.5	36.5	25.5	10.4	8.6	9.1 ± 14.8	17	1	6
Total	484	340	824	242.0	170.0	206.0	148.9	136.0	157.0	18	7	214

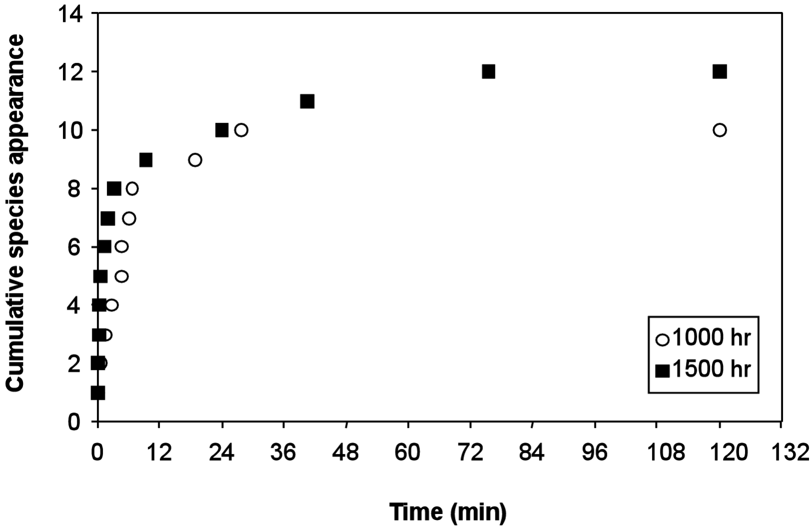

FIGURE 6. Cumulative species appearance between morning (10:00 h) and afternoon (15:00 h) observations

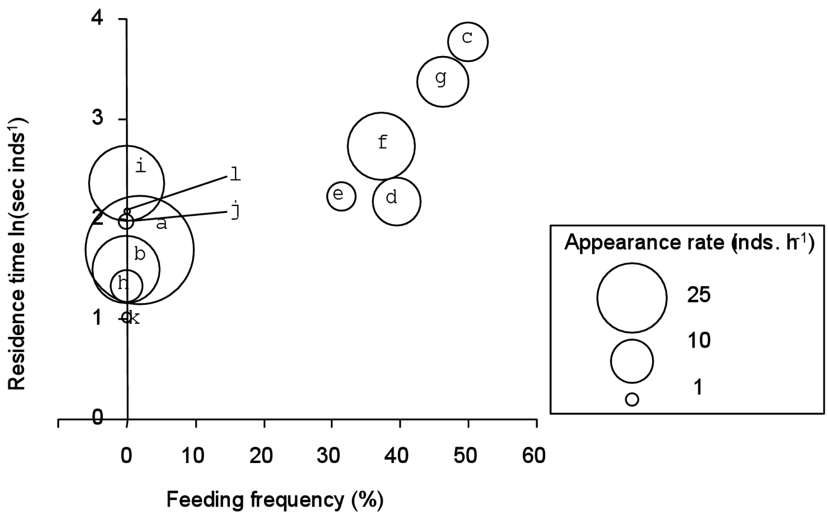

FIGURE 7. Appearance rate distribution between residence time and feeding frequency of the observed reef fishes. a: *Caesio caerulaurea*, b: *Siganus guttatus*, c: *Cephalopholis boenak*, d: *Labroides* sp., e: *Lutjanus* sp., f: *Scarus* sp., g: *Scolopsis bilineatus*, h: *Caesio teres*, i: *Liza subviridis*, j: *Labroides dimidiatus*, k: *Monodachtylus argenteus*, l: *Dasyatis* sp.

The video images were clearer when the distance between the video camera and the artificial reef module was 160 cm instead of 260 cm. Underwater visibility decreases significantly with distance due to light scattering and absorption by suspended particles in the water. Visibility at the sampling site was less than 10 m throughout the study period. Thus, it is advisable to set a shorter distance between the video camera and the object in low visibility areas, without compromising the field of view as much as possible. However, if the visibility permits, consideration should be taken to set a wider field of view for better observation of reef fishes. The compensation point between distance to object and field of view may therefore be different among reef sites and season and preliminary video sampling should be carried out to achieve the best results.

Color replication was different between the morning (1000 h) and afternoon (1500 h) recordings. When low morning light intensities penetrate the water, the shorter red and yellow light spectrum easily dissipates leaving the longer blue light wavelength, accentuating a blue hue in the video images. Using the red color filter compensates for the lack of the red spectrum and provides a truer color replication. In contrast, the amount of red light underwater is considerable under the strong afternoon light intensity and using the red color filter over-emphasizes the red hue in the video images. Thus, it is advisable to use a red color filter in the morning but not in the afternoon.

Many studies have determined that observation or survey time is an important parameter affecting fish community assessments (e.g. Bortone et al. 1989; Tessier et al. 2005). We did not change the video recording length in order to avoid bias due to time variations. The survey time was set at 2 hours each for the morning and afternoon samplings. While the species accumulation did not reach its asymptotes during the observations, the rate of species accumulation was very low after 35 minutes that further observation would be of little benefit (Figure 6). Similarly, Willis and Babcock (2000) found 25–30 minutes to be optimal for *Pagrus auratus* and *Parapercis colias* in New Zealand videography experiments, and Cappo et al. (2004) gave an average time to maximum cumulative species occurrence at 23 ± 16 minutes for Australian tropical fish. Based on our results we suggest that an observation time of >25 minutes suffices for studies where species community is the main objective. However, the survey time could readily be increased to target rare or cryptic species.

VIDEO DATA ANALYSIS

Appearance rates were high for schooling fishes such as *Caesio caerulaurea* and low for solitary species such as *Cephalopholis boenak*. However, mean residence time was shorter for schooling fishes than solitary swimmers (Figure 7). The artificial reef may be effective in attracting solitary species that seek potential dwelling grounds. However, they may be more territorial and exclude conspecifics thereby limiting their density in the artificial reef.

Feeding frequency is considered one of the indicators of the fish attraction to the artificial reef. Schooling fishes showed low feeding frequency while solitary swimmers had high feeding frequency (Table 2), suggesting a relatively direct attraction of solitary species to the artificial reef. Schooling fishes such as Caesionids are primarily planktivores that would not be expected to be actively feeding on the reef module and thus presumably aggregate around the reef due to factors other than feeding such as escape from predation pressure. A significant correlation was obtained between the feeding frequency and mean residence time for the high feeding frequency group ($p<0.05$, Figure 7), suggesting that long residence time is usually coupled with high feeding frequency. Therefore, the effectiveness of the artificial reef as a fish aggregating device may be significant in solitary swimmers but less so for schooling fishes.

Underwater visual census is important to assess fish aggregations; only with direct involvement in the natural environment can a wide range of information be gathered, including the human capacity of stereoscopic vision. But visual sampling is limited by the human capacity to intercept visual cues and by depth constraints. The use of underwater videography census such as this study proved to be useful. It can be valuable in particular conditions such as in the case of strong recruitment or high abundance and during regular monitoring for key species. Additionally, the video census could also be handled by a non-fish specialist, permit a larger data set in space and time, and data processing could be also computerized.

Further monitoring is necessary to determine whether the use of artificial reefs as a resource enhancement tool is effective so as to advocate the use of well-planned artificial reefs. The underwater videography could be used jointly with other census to obtain a better understanding of fish behavior and aggregations, and to broaden the option of suitable designs for artificial reef programs in the future.

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REFERENCES

Baine, M. 2001. Artificial reefs: A review of their design, application, management and performance. *Ocean & Coastal Management* 44: 241–259.

Bell, M. & Hall. J.W. 1994. Effects of hurricane hugo on South Carolina's Marine Artificial Reefs. *Bulletin of Marine Science* 55(2-3): 836-847.

Bell, M., Moore, C.J. & Murphey. S.W. 1989. Utilization of manufactured reef structures in South Carolina's Marine Artificial Reef program. *Bulletin of Marine Science* 44: 818-830.

Bortone, S.A., Kimmel, J.J. & Bundrick. C.M. 1989. A comparison of three methods for visually assessing reef fish communities: Time and area compensated. *Northeast Gulf Science* 10: 85-96.

Brock, R.E. 1982. A critique of the visual census method for assessing coral reef fish populations. *Bulletin of Marine Science* 32: 269-276.

Cappo, M., Speare P. & De'ath. G. 2004. Comparison of baited remote underwater video stations (BRUVS) and prawn (shrimp) trawls for assessments of fish biodiversity in inter-reefal areas of the Great Barrier Reef Marine Park. *Journal of Experimental Marine Biology and Ecology* 302: 123-152.

Ch'ng, K.L. & Thomas, C. 1990. Artificial reef program in Malaysia. In *Towards an integrated management of tropical coastal resources,* edited by Chou, L. M., T. Chua, E., H.W. Khoo, P.E. Lim, J.N. Paw, G.T. Silvestre, M.J. Valencia, A.T. White, P.K., Wong. ICLARM Conference Proceedings 22. pp. 305-309.

Chapman, C., Johnstone, A. Dunn, J. & Creasey, D. 1974. Reactions of fish to sound generated by diver's open-circuit underwater breathing apparatus. *Marine Biology* 27: 357-366.

Chua, Y.Y. & Chou, L.M. 1994. The use of artificial reefs in enhancing fish communities in Singapore. *Hydrobiologia* 285: 177-187.

De Silva, M.W.R.N. & Ridzwan Abdul Rahman. 1982. *Coral reef survey of Pulau Paya/Segantang group of islands, Kedah, Malaysia: Expedition report and recommendations for management*. Report produced under WWF Project Mal. 41/82. Universiti Pertanian Malaysia, Serdang.

Francour, P., Liret, C. & Harvey, E. 1999. Comparison of fish abundance estimates made by remote underwater video and visual census. *Naturalista Siciliana*. 23: 155–168.

Jensen, A.C. (ed.) 1997. European Artificial Reef Research. *Proceedings of the First EARRN Conference, March 1996,* Ancona, Italy.

Parker, R.O.Jr. 1990. Tagging studies and diver observations of fish populations on live-bottom reefs of the U.S. southeastern coast. *Bulletin of Marine Science* 46: 749-760.

Rilov, G. & Benayahu, Y. 2000. Fish assemblage on natural versus vertical artificial reefs: the rehabilitation perspective. *Marine Biology* 136: 931-942.

Russell, B.C., Talbot, F.H., Anderson, G.R.V. & Goldman, B. 1978. Collection and sampling of reef fishes. In *Coral reefs: research methods,* edited by D. R. Stoddart and R. E. Johannes. p. 329-345 UNESCO, Paris.

Satapoomin, U. 1997. Fish aggregation at the artificial reefs. In *The effect of artificial reef installation on the bioscioeconomics of small-scale fisheries in Ranong Province, Thailand*. Bay of Bengal Programme. Nagaraj & Co., Madras.

Takagi, N., Moriguchi, A. Kimoto, K. & Arai, K. 1997. The observation of the fishes' behavior around an artificial reef with an underwater television camera – about using a tethered underwater television camera without propulsion. *Technological Report of the National Research Institute of Fisheries Engineering* 19: 29-44.

Tessier E., Chabanet, P. Pothin, K. Soria, M. & Lasserre. G. 2005. Visual censuses of tropical fish aggregations on artificial reefs: slate versus video recording techniques. *Journal of Experimental Marine B2iology and Ecology* 315: 17-30.

Thresher, R.E. & Gunn, J.S. 1986. Comparative analysis of visual census techniques for highly mobile, reef-associated piscivores (Carangidae). *Environmental Biology of Fishes* 172: 93-116.

Toda, T., Okashita, T., Maekawa, T., Kee, B.A.A., Kushairi, M.M.R., Nakajima, R., Chen, W., Takahashi, K.T., Othman, B.H.R. & Terazaki, M. 2007. Community structures of coral reefs around Peninsular Malaysia. *Journal of Oceanography* 63: 113-123.

Willis, T.J. & Babcock, R.C. 2000. A baited underwater video system for the determination of relative density of carnivorous reef fish. *Marine and Freshwater Research* 51: 755-763.

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